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ADAPTATION OF THE FORM OF FURNACE TO THE KIND OF FUEL CONSUMED—CONSIDERED PARTICULARLY IN REFERENCE TO STEAM ENGINE BOILERS.

It is surprising to find how little reference has been made in works, professedly written upon steam engines, to a most important branch of the subject—we mean the influence different kinds of fuel have over the arrangement of the furnace and the fire surface of the boiler. The proportion of fire surface necessary to evaporate a given quantity of water and the economical arrangement of this fire surface, are matters fully discussed in such treatises, but the deficiency above named will be found in all.

A sufficient reason for this may be found in the fact that, in England but one kind of fuel is used, and its varieties are so little different from each other that no necessity exists for an investigation. In the United States the case is far different. All sorts of fuel are used, from the most different varieties of wood through the whole range of bituminous coals by imperceptible shades, to the most perfect anthracites. The most indifferent observer cannot fail to remark the variety in the mode of combustion incident to these various kinds of fuel, and the consequent changes to be made in the mode of heating by them. A common, though not altogether accurate rule, is the result of general observation, viz. that the flame should reach the vessel to be heated—but this is very erroneously stated in the ordinary saying that those fuels give most heat which yield most flame.

It might be supposed that the attempts to burn anthracite in the furnaces of steam boilers would have led to useful results. That such has been the case we do not doubt, but the information so gained has never been given to the public in any well digested form, being more frequently made the basis of a patent, which necessarily must become partial and restricted in its application.

Before pointing out the *desiderata* in our knowledge of fuel, it may not be amiss to show how far the information already acquired extends. The

most useful and exact results have been attained by the investigations of Lavoisier, Laplace, Guy Lussac, Berthier, Peclet, Rumford and Marcus Bull. These philosophers have determined with great nicety, the quantity of heat given out in the combustion of various bodies, and although pursueing totally different methods, they have arrived at results somewhat discrepent, yet we have in this very difference the guarantee of the truth of the average of the whole. While the methods have sufficiently determined the *quantity* of heat given out, they in no wise refer to its *intensity* and this is oneof our *desiderata;* while the former of these must always remain constant it is obvious that the latter, the *intenssty,* varies with the form of furnace as well as the mass of combustible, and is as yet undetermined in the different kinds of fuel. This branch of the subject from the difficulties attendant upon its experimental investigation is yet almost untouched.

The next point to which attention is necessary is the *radiating* power of different combustibles. It is known that all heat is either transmitted by *communication* or thrown off by *radiation.* By the first of these methods the heated gases arising from combustion are made the vehicles for carrying and communicating the heat to those objects against which they are driven—by the latter, the heat from an open grate or fire-place warms a room. The amount of heat distributed by radiation from burnidg bodies, has generally been overlooked as inconsiderable, but Peclet has proved from extensive experiment that it is as much as one-fourth or one-third of the whole heat obtained. Now unless provision is made for intercepting this heat, a large portion of the useful effect of fuel is lost, and as charcoal and bituminous coal as well as anthracite, furnish a greater proportion of radiant heat than wood, unless it is in a large quantity, it follows that different arrangements are necessary. The disposition of parts required to intercept *all* of this heat, would be that of a spherical fire surface entirely surrounded with water, an arrangement in strictness manifestly impossible but to which close approximations can be, and have been made.

Flame also gives out a quantity of heat in the same manner and hence when drawn through winding passages, distributes it both by radiation and conduction. It is on this principle that the tubes in locomotive boilers are advantageous when wood is used—and on the same principle we might doubt their utility when anthracite is burned. We have every reason to believe that the larger the mass of fuel and the greater the intensity of the heat,the greater will be the proportion given out by radiation. This rule will indicate the necessity of a change in the form of furnace, as we in crease our efforts to obtain steam rapidly, as in locomotives.

The heat at which the fuel enters the into combustion, must also be borne in mind, when we vary the form of furnace—and beside this, the temperature at which the smoke, gases and other volatile products burn, is also an important datum. Thus while certain substances require a pluntiful sup. ply of air through large opeuings, and obtain this by the mere draught of the chimney—others require a more concentrated blast and need the aid of

blowers to maintain a vivid combustion. Immediately connected with this is the consideration of the density of fuel and its porosity. Such substances as anthracite having an exceedingly compact structure will require an arrangement totally different from that required by wood. What is sometimes called the second burning, or the combustion of certain gases resulting from an incomplete burning of the fuel, may be turned to profit, or suffered to go to waste and produce serious injury, by the unexpected and dangerous degree of heat communicated to unprotected parts of the vicinity of the boiler. This second combustion may be made to take place immediately over the fuel by introducing air directly into this part of the furnace.

The disposition to form *clinker*, owing to the fusibility of the ashes of some varieties of anthracite, is also a circumstance to be noted and provided for--as by this means the fuel may become united into a solid cake impermeable to air, and the sides of the furnace so coated and roughened by it so as to prevent cleaning without running great risk.

In using anthracite there must be some contrivance for gradually feeding the fuel, and introducing it in a heated state; there are many ways of accomplishing this object without any loss of heat or power

A method which appears to have been successful in the use of hard coal, is to introduce the coal by a hopper placed over or beside the boiler and to have a small aperture at the side to regulate its even disposition over a considerable surface while the boiler is placed quite close to the fuel. The fire in this instance was blown by a fan. The testimonies of all who have used hard coals, unite in insisting upon the necessity of a large extent of burning fuel at no great distance from the boiler surface.

The subject is evidently open for much experiment and consideration. We have not pretended to enter into all its bearings—leaving that to some one better qualified, by the experience of actual trial.

Errata.—Number for October 1st—Lattice Bridges, page 196, 14th line from bottom, a comma after the words "ground," and "braces," 6th line from bottom, "examination" should be "enumeration." Page 197, 1st line, for "supporters" read "supports," 15th line from top, omit the word "ties." Page 198, 6th line from bottom, "insert" should be "invert." Page 200, 16 line from bottom of article, "pins 3 × 12," read "ties 3 × 12."

To the Editors of the American Railroad Journal and Mechanics' Magazine.

Gentlemen:—I notice in the Railroad Journal of September 1st, a statement, that an "eight-wheeled locomotive engine built by Mr. Norris of Philadelphia, left Boston for Worcester, with a load of 150 tons of merchandize, etc.," together with some remarks and conclusions thereon, which leads me to suppose that you and such of your readers as feel an interest in this subject, might be gratified with a more minute detail of the facts connected with that trial.

Having been one of the committee appointed by the Board of Directors for the Western road, to attend to this matter, I can without much incon-

venience to myself give you some of the facts in relation to said trial. The load in question was as follows:—

Plaister, - - - - - -	117	tons	1200 lbs.
80 bales cotton, - - - - -	16	"	464 "
325 casks spikes, - - - - -	17	"	125 "
	150	"	1789 "
37 cars, - - - - - -	77	"	900 "
Tender full of wood and water, -	12	"	1920 "
Gross load, - - - -	241	tons	609 lbs.
2000 lbs. to the ton.			

With this load the engine started from Boston about 1 o'clock, P. M., on the 19th of August last. The weather was fair, wind very light, and all the attendent circumstances as favorable for the movement of a heavy load as could be desired.

The first ascending grade was at the rate of 23 ft. per mile, and 1900 ft. in extent; average speed on this grade, about 1200 ft. per minute.

The next upward grade, 13 ft. per mile; extends 5880 ft. On the last part of this grade speed was reduced to about 600 ft. per minute; and on a grade of 29½ and 3800 ft. in extent, speed was reduced to about 576 ft. per minute.

After passing over several miles of level road or light grades, at a speed varying from 1050 to 1344 ft. per minute, the train entered upon a grade of 27 ft. per mile, 3780 ft. in extent; on this grade speed was reduced to 624 ft. per minute.

About 11 miles from Boston, the engine encountered one of the maximum grades of this, (the Boston and Worcester,) road: say 30 ft. to the mile, 13,340 ft. in extent. This plain was entered upon from a descending grade, at a speed of about 1300 ft. per minute; the train proceeded about one mile over that part of the plain, which was straight, or nearly so, gradually reducing speed to about 408 ft. per minute, until entering upon a curve of about 1200 ft. radius, where the engine reached the maximum of her adhesive power. Here the question was settled, not only, that the power of the engine was inadequate to this load on the high grades of the Western road, but that she was overloaded, even for the Worcester road; her power being barely equal to moving the load over the maximum grades of the latter on straight lines, at the rate of about 4 or 4½ miles per hour. By the application of sand upon the rails, an additional amount of adhesive power was borrowed, sufficient to enable her to surmount the inclination, as also, all the other maximum grades of that road, which in the aggregate, amount to about 8 or 9 miles.

The next morning about 10 o'clock, this engine started from Worcester, on the *Western* road, with the same load, together with a small empty passenger car. On entering upon the first ascending grade of 42 ft. per mile, her wheels slipped. The train was then run back, about 1 mile, and again

entered upon this inclination, at greater speed, say about 12 or 1300 ft. per minute. The wheels again slipped, and the load could not be moved forward with all the aid which sand upon the rails could give. Five cars were then detached from the train, the gross weight of which was 30 tons 1835 lbs., reducing the weight of merchandize to 130 tons 1009 lbs—and gross weight of the whole load to about 210 tons. With this load the engine surmounted the summit grade in Charlton, without the use of sand, at the rate of about 4 miles per hour. Her water being out, and her wood nearly so, on the last and hardest part of this grade, I presume that her load was reduced to about 205 tons gross.

On the day following, it was agreed by Mr. Imlay, (Mr. Norris' Agent for these trials,) and myself, that a trial should be made, to ascertain the relative power of this engine, as compared with the Lowell engines, (that being the only kind used upon the Western road,) and as proportioned the weights resting upon their respective drivers.

The weight on the drivers of the Norris engine,	19,220 lbs.
That upon the drivers of the Lowell engine,	16,150 "

The peculiar mode of connection of the engine with the tender, of the Norris engine, together with the position of its cylinders, induced the supposition that when in action, under a full head of steam, there would be a greater *additional* amount of weight thrown upon his drivers, than is usual with an engine acting upon its tender by a horizontal draft. The drivers of these engines were consequently weighed with the application of a full head of steam, (the engine being made fast,) while the driving wheels were upon the scale, and in this state the drivers of the Norris engine weighed 21,070 lbs. Showing an addition to its weight by the steam of 1850 pounds. The lowell engine drivers in this manner weighed 17,155 lbs. addition by steam 1005 lbs. Twenty-seven cars were then attached to the Norris engine, with which she commenced assending the plain near Springfield at the rate of about 7 or 8 miles an hour, and gradually diminished her speed until her adhesive power was overcome having proceeded up the plain about one mile. The train was then run back, six cars detached and the engine started again, with 21 cars, the gross weight of which was 129 tons 1698 lbs., with this load she ascended to the top of this plain in 26 minutes, being at the rate of 5.63 miles per hour.

The Lowell engine then took 17 cars weighing 99 tons 42 lbs. and passed up this grade in 14¾ minutes, rate 9.92 miles per hour. This being something less than a pro rata load for her, and obviously much less than her power was equal to carrying, two more cars were added, increasing her load to 117 tons 218 lbs. With this load she passed up the grade in 21½ minutes, at the rate of 6.8 per hour.

The first 8200 ft. of this plain ascends at the rate of 60 ft. per mile. Next 2000 ft. 66 ft.—then 700 ft. 46;—remainder 60 feet—length of the plain 2.44 miles.

As before stated the weight of the Norris engine drivers, with steam on 21,070 lbs. That of the Lowell, with steam 17,155 lbs.

Gross weight of the Norris engine's load, - -	259,698 lbs.
Tender when full of wood and water 25,950 lbs.; but having stood after weighing 3 or 4 hours, and been run a part of the way up the plain before making this trip, I assume her weight on the drivers at the time of her performance to have been about 3 tons less, leaving - - -	22,920
Total weight of merchandize, cars and tender, - -	282,618 lbs.

If 21,070 : 282,618 : : 17,155=230,104 lbs.

To make the performance of the Lowell engine exactly equal to that of the Norris, in proportion to weight upon their respective drivers, she should have taken up 230,104 lbs., in 26 minutes.

Gross weight of the 19 cars she did take up, - -	234,418 lbs.
Tender 14,000, less for loss of wood and water 2,000 lbs.	12,000
	246,418
	230,104
Difference,	16,314 lbs.

Lowell engine 4 wheels, 2 drivers, $4\frac{1}{2}$ ft. diameter, 12 inch cylinder, 18 inch stroke, steam pressure in the boiler 90.

Norris engine 8 wheels, 4 drivers, 4 ft. diameter, $12\frac{1}{2}$ inch cylinder, 20 incher stroke, steam pressure 130.

Yours, etc.,

WILLIAM JACKSON.

Newton, Mass. Oct. 8th, 1840.

REPORT OF JAMES RENWICK, LL.D., ON MODE OF SUPPLYING THE ERIE CANAL WITH WATER FROM LOCKPORT TO THE CAYUGA MARSHES.

(Continued from page 238.)

(1) In order that the water which descends at Lockport into the Rochester level shall not be backed up, and prevented from flowing forward to supply the levels beneath, it will be necessary that it should have a free course through the aqueduct at Rochester. The arrangements proposed by the engineers in the plan of the enlarged canal will be of use in effecting this object. These are to lower the bottom of the canal immediately on leaving the aqueduct, one foot; to give the bed of the canal between the aqueduct and the first lock a slope of an inch to the mile; and further to incline the bed near the lock until the depth be increased a foot. It will be in addition necessary to guard against any injudicious use of the waters of the Genessee river. It is obvious from the facts heretofore cited, that whenever water is introduced thence, in such abundance as to raise the canal, to the east of the aqueduct, above its normal depth, it then becomes necessary to draw all the supply of the eastern division from the river, and that a small additional increase in the depth may cause a current westward. The gate of the first lock therefore, instead of being raised four inches above the proposed surface of the canal, ought to be at that level, or

even at a small depth beneath it; and a weir ought to be provided of sufficient extent to pass down the water required beneath, without the necessity of any rise in the level of the surface in the aqueduct. Any injudicious use of the feeder ought to be counteracted, along with flushes arising from a frequent use of the lock by which vessels pass from the river into the feeder, by a regulating waste wier, so placed as to return all excess of water immediately to the channel of the river. Great stress is laid on these points inasmuch as error in either structure or management, in this part of the canal will effectually defeat every provision which may be made in other parts for drawing the whole supply from Lake Erie.

2. The changes which it is proposed by the engineers to make in the enlargement of the canal, between Black Rock and Lockport, seem to ensure that a sufficient quantity of water shall always reach the head of the system of locks. No modification or change of this part of the plan would appear to be required. It is otherwise with the long level which extends from the foot of the locks at Lockport to the first lock east of Rochester, a distance of 64 miles. In respect to this, two different opinions are entertained, the one urges a general increase in the slope of the bed of the canal up to an inch or even 1½6 in per mile. The other, admitting a small increase in the slope which can be easily attained, proposes to compensate for want of slope by an increase in the dimensions of the canal. The latter plan divides itself into two distinct propositions. In the one it is proposed to maintain a constant depth in the canal. The other is founded on the plan of making the depth diminish in accordance with the expenditure of water in leakage &c. By the latter method an increase will be gained in the slope of the surface of the canal, and we shall see that it is possible so to unite and modify the two propositions of the second plan, as to give the canal all the advantages to be derived from the first. There is a fixed point in the bed of the canal which must control all the changes which are to be made in its structure. This is the floor of the aqueduct at Rochester. By the aid of much exertion and expensive excavation in rock, it has been found practicable to lower this one foot beneath the bottom of the present aqueduct. It is too late to enquire whether it might not have been possible by the use of iron as the material for the aqueduct instead of stone, to have lowered the channel still further. The slope of the bed of the canal is at present ½ inch to the mile, and from the foot of the locks at Lockport to the first lock east of that place is 32 inches in a distance of 64 miles. Sinking the aqueduct 12 inches gives a slope of 44 inches, or 0.6875 inch per mile. The plan of deepening the canal to the east of the Rochester aqueduct, and increasing the slope of its bed to the first lock has already been referred to but it is not necessary that this change should enter into the question at present under consideration.

It is proposed, and the proposition appears to have been adopted, to make the depth of the canal in the city of Rochester seven feet. It may therefore stand 9 feet deep at the first lock, and will then allow of a depression c

two feet. Mr. Barrett advises that the depth of the canal at Lockport be made 8 feet. Adding this additional depth to the slope of the bed we have 56 inches or $\frac{7}{8}$ths of an inch per mile, for the slope of the surface from Lockport to Rochester.

It will be expedient in addition, to maintain the canal at the constant depth of 8 feet for seventeen miles to the eastwards of Lockport. This will be rendered easy and advisable in consequence of the possibility of introducing a feeder into the canal at this place through the valley of the Oak Orchard Creek. This feeder commands the waters of that stream and the Tonnewanda. It has by an accurate guage been determined that they are capable of furnishing in the driest seasons 1400 cubic feet per minute. On the course of this feeder it is reported that a reservoir might be formed of 1000 acres, which can be filled from the Tonnewanda.

It is therefore proposed that the canal be carried forward from Lockport as far as the Oak Orchard feeder with a slope in both bottom and bank of 0.6875 inches per mile, being the same that it has been seen will be practicable along the whole line of bed. At this point it is proposed that the depth of water shall begin to decrease, and shall continue so to do until it attain a depth of seven feet.

The rate at which water flows in a given channel depends upon the slope of its surface, and not on that of its bed. We have therefore to add in this case to the regular slope of the bed of 0.6875 per mile, the foot gained by diminishing the depth from 8 ft. to 7 ft. This will give in the remaining 47 miles a superficial inclination of 44 3 in. or very nearly one inch per mile. In this way then nearly as great a slope as has been considered necessary by either engineer may be attained.

It remains to be inquired what dimensions shall be given to the transverse sections of the canal, which when taken in connection with these depths, constant for 17 miles, and these diminishing from 8 ft to 7 ft, will suffice for the flow of the requisite quantity of water.

Mr. Barrett has calculated with great labour and care several tables of the dimensions of the canal upon different hypothesis of depth and slope. The basis on which two of these rest are sufficiently near the circumstances of the mode we propose to permit the use of the dimensions thus calculated. The first of these is adapted to the constant depth of 8 ft, and from it the dimensions for the first seventeen miles to the eastward of Lockport may be taken in the nearest round numbers. These would give for the surface breadth of the canal at Lockport 93 feet, and a diminution thence at the rate of 6 in. per mile until at the end of the seventeenth mile it becomes 84$\frac{1}{2}$ ft.

By the second table of Mr. Barrett it would appear that a canal of decreasing depth losing 200 cubic feet per mile per minute would diminish from the latter dimension to a breadth of 70 ft and depth of 7 feet in the space of 31 miles. It would not however do to permit the dimensions to diminish thus rapidly, for the canal, if continued of uniform dimension for

the remaining sixteen miles and losing, as estimated, 200 cubic feet per mile per minute, could not be maintained of a constant depth. It is therefore proposed that the diminution in the dimensions of the canal, until it enter the city of Rochester, when its figure is to be altered, should be regular. Taking this distance at 43½ miles, the diminution in the surface breadth of the canal will be at the rate of 4 in. per mile. The decrease in depth between the junction of the Oak orchard feeder and the entrance of the Rochester aqueduct will be 12 inches, or somewhat more than ¼ in. per mile.

Were recourse had to strict mathematical calculation, it would be found that the canal from Lockport to the Oak Orchard feeder having the dimensions proposed will pass more water than is exhibited in the tables of Mr. Barrett, in consequence of the inclination being a little greater than he has assumed. So also similar calculations would show a demand on the Oak Orchard feeder of about 2000 cubic feet per minute in order to meet the increased rapidity of the current. This demand will not however occur in practice, as the change in the slope of the surface will take place insensibly and there will be in general a flush of water at the foot of the locks at Lockport. In the use of the Oak Orchard feeder, therefore, it will be necessary to observe precautions of a similar character to those which have been pointed out in the case of the Genesee feeder. Thus the feeder ought not to be used except when the canal falls below its normal depth of 8 ft, at the place of junction, and should not be kept open after the depth had again reached that limit.

The whole line thus proposed if strictly calculated will show an excess of water running in it. This is necessary as a precaution, and can be productive of no inconvenience in practice Should the supply be over abundant, it will only be necessary to allow the depth of water at Lockport to subside, and the defeat will be remedied. It is however believed that the quantity which will actually flow in the canal cannot hold out with the calculation, and that the provision for an apparent excess is wise and necessary, obstructions which cannot be allowed for in any calculaton exist, and taking those which have been stated, in connection with the curvature of the line of the canal, there would appear to be no danger of the current exceeding ½ mile per hour.

Such a current, or one more rapid, is not to be objected to, under the circumstances of the case. The great amount of freight is a descending trade. The boats which pass downwards heavily laden, return almost empty, and thus a current from Lockport towards Rochester, so far from being objectionable, must be a great facility to the trade of the canal. Had the canal been to construct anew, and been independent of the interests on its banks, a greater slope than one of an inch to the mile would have been recommended. The canal is in fact under circumstances which entitle it to be considered until it reaches Rochester, rather as a navigable feeder than as a mere navigation. We might therefore have had recourse to the

instances of such works as have been erected in Europe, for the double purpose of navigation and conveying water. Of these we may cite that of the canal del'Ourcy, the slope of whose beds is more than 6 inches per mile, and which is notwithstanding easily navigable in either direction. The navigable feeder of the Union canal in Pennsylvania has a slope of four tenths of a foot per mile, and there are instances where navigable channels have had even greater inclinations.

3. The water, in entering the aqueduct at Rochester will be much less retarded than it now is. The area of the new aqueduct will bear a greater proportion to that of the canal than at present, and the abrupt angle at the eastern end will be much improved. Still, an allowance ought to be made for this obstruction, which may be estimated as equivalent to a fall of two inches. No water therefore ought to be permitted to flow from the Genesee feeder until the depth of that at the eastern end of the aqueduct fall below six feet ten inches.

4. It has been proposed to place a guard lock at a short distance to the west of Rochester, for the purpose of forming a reservoir of water in the bed of the canal itself. There is no valuable object, as far as can be perceived, to be gained by this. The water is not needed in the Rochester level, but is required for the supply of those beneath. All that can be sent forward will often be demanded for this purpose, and when there is any surplus it ought not to be retained in the Rochester level, but if possible in a reservoir fed by it, and capable of being drawn upon by those below. The introduction of such a gate will enhance the greatest of the existing evils, namely, the discharge of water which is actually wanted at lower points over waste gates near the points where it enters the canal.

It may be here stated that there is a possibility of increasing the slope from Lockport a few inches by adopting the asphaltic mastic, as a lining for the aqueduct. This has very important advantages, and may at the present moment be obtained at a very low rate.

5. It appears to be in contemplation to establish stop-gates at various places along the line of the canal. These will, it is presumed, be similar in their structure and adjuncts to the upper gate of a lock. The canal will therefore, at these points, be diminished to less than half its ordinary area. In introducing these gates, it must be considered that when a contraction in a stream takes place, it acts as as a bar, to accumulate the water above it, until the slope of the surface becomes sufficient to discharge all which has accumulated; it will therefore be necessary to allow at the entrace of each stop-gate such slope as will not retard the current above them; within their walls such a slope must be admitted as will cause an increase in the velocity of the current adequate to pass the quantity which flows in the full width of the canal, through the narrow space.

Unless an extra slope be allowed in such places, either the canal will not run full, or, if full, the quantity which flows will be governed by the area of the stop-gates, not by that of the rest of the canal. It appears pro-

bable, that at least, four such gates will be considered necessary between Lockport and Rochester, and a fall of at least an inch in the bed of the canal ought to be made at each of them over and above what has already been stated as proper and necessary.

6. The slope of the surface of the canal will be regulated by the lock gate and discharging weir east of Rochester, and by the level at which the edges of the waste gates are maintained. The depression of the former has already been recommended in order that the water in the long level may flow regularly forward without obstruction. The lateral waste weirs ought to be raised of solid and permanent materials up to that level at which it is intended to keep the water of the canal, and the arrangements cannot be considered as perfect until it shall appear that no water runs to mere waste. When water is scarce it may be expedient to raise the waste weirs some higher by means of plank, in order that there may be no loss by the overflow of waves. The discharging weir at the lock east of Rochester, ought to be sunk so low that the quantity necessary to supply the leakage and evaporation of the lower levels shall be certainly passed over it, without the necessity of raising the surface of the water in its neighborhood.

7. At this lock, and at the four which next succeed it to the east, the plan of obtaining baisins of considerable breadth at the head of each lock, for the purpose of meeting the demand of an unusually rapid lockage, as proposed by Judge Roberts, will be attended with much benefit.

8. An extension of the canal in width at Lockport, even beyond the limits heretofore assigned, so that the water passed through the locks may have room to expand itself, until it shall set the water below it in motion, will be also advantageous. It is obvious that the double system of combined locks must pass twice as much water into the lower level as a single lock carrying the same trade, would, and it is farther clear, that a single isolated lock might pass as many vessels in a day, as the double system when combined. On this is founded a suggestion for equalizing the flow of the water after it has passed the locks at Lockport. Place a guard gate at the point where the embankment on the north side of the canal commences, the surfare of whose gates shall be level with that of the gates of the lower lock of the system. This gate will pass as many vessels, in a given time as the combined system, but will use in lockage no more than half the quantity of water. During a time when a great number of boats are passing, half the water may accumulate in this basin formed between the lower lock of the system and this guard lock to be discharged where the lockage is less frequent. Even below this point it will be well to give to the canal all the breadth that it can conveniently assume, and the waste weir at Lockport ought to be closed altogether. At present there is no waste weir from that at Lockport, for nine miles to the east. One which is favorably situated about six miles to the east, has been closed and has gone out of use. I should propose that it be refitted and reopened. It will

be quite near enough to prevent the water accumulating to a dangerous extent after passing the locks at Lockport, and yet so distant as not to be affected by waves or sudden and temporary flushes. Indeed, I cannot but consider the closing of the waste weir at Lockport by an embankment as all important to the assurance of being able to feed the canal east of Rochester without drawing upon the water of the Genesee river in seasons of drought.

Among the objections usually made to the double system of combined locks, is the quantity of water they require for lockage. Such, however, is the demand for water on the lower levels that all which is passed through them might be of service. In times however, when the passage of boats through the locks is frequent, the water discharged from them in large quantities, forms a wave, and does not, for an appreciable interval cause any motion in the canal below. The flushes of water arising from frequent lockage are therefore principally discharged at the nearest waste weir. This discharge ought, at all events, to be rendered as small as possible, and waste weirs ought to be no more frequent than is absolutely necessary to preserve the canal from risk of break.

9. Were the canal to be laid out anew, it would be best to seek for a new route from Lockport, eastward, so chosen that the locks which are now combined in Lockport might be distributed at distances as nearly equal as possible. The interests which have been created by the canal in its present route are of such importance as to forbid any changes, except such as are slight, in the line of the canal. Lockport itself owes much of its present importance, and all which is hoped for it in future, to its position at the point where so great a fall is accumulated. If in the arrangements which are necessary to feed the canal from Lockport to the Cayuga marshes, inconvenience may arise to the towns and villages on its banks; it might be well for their inhabitants to consider whether such inconveniences had not better be patiently submitted to, than a complete change in the route of the canal, which every other interest except that of their local property seems to demand.

10. It is proposed by the engineers to line the bottom of the canal wherever it is cut to the rock, and to puddle its banks. This will be efficient in preventing any excessve leakage. It is also proposed to increase the slope of the banks from $1\frac{1}{2} : 1$ to $2 : 1$. This will remedy to some extent, the filling up of the canal by a change in the figure of its section, growing out of the looseness of the material. The finishing of the counter-bank of the canal is of equal or even superior importance. Whenever this is formed by a cut or by an embankment, and not by the mere spreading of the water until it is confined by natural surface of rising grounds, there ought to be a *berm* or shelf on a level with the surface of the water. This berm should be from 18 in. to 2 feet in breadth, and should be sown with aquatic plants or covered with sod from marshes. The counter-bank itself should be formed with as much precision as the towing path,

although it will only require the neighboring earth as a material, and its slope to the berm ought to be sodded or sown with grass seed. The top of the bank should slope from the canal towards a counter-ditch by which the surface water of the country may be intercepted and carried forward to a proper place of discharge under the canal. In deep cuts the earth should rise from this ditch at a slope which it is capable of maintaining and should be sodded or sown with grass seed. On the tow-path side, a similar berm, covered with chip stone or course gravel, ought to be formed, and except on side lying ground, a counter-ditch, to intercept surface waters, ought to be cut. A great improvement has already been made in the towing-path by making it highest on the side nearest the canal.

11. The canal being fed with pure and clear water from lake Erie, the slope of its sides being made such that the earth can sustain itself; the caving in of the bank prevented by finishing it as carefully as the towing-path, and providing both with a berm; the dropping of earth from deep cuts, and the wash of the surface waters being excluded, there would seem to be no reason why the canal should have its area diminished beyond what might from time to time be washed out, by opening waste gates during seasons of flood, or of inactivity in the trade. There would remain the obstruction of the aquatic weeds. For these there is probably no other remedy but to keep them closely cut, although it might be worth the trial whether salt or costic lime might not effect their destruction at an expense less than the labor of cutting them.

12. Admitting that the canal constructed upon the principles which have been stated, from Lockport to Rochester, will convey to the lock east of the latter place all the water which may be required to feed it thence to the Cayuga level, it is, notwithstandiug, certain that the draught through the locks may be, in some cases, so rapid as not to be identically supplied without delay. In seasons of excessive drought, or in case of breaches in the canal, the calculated quantity of water may not come forward as wanted. For these and various other reasons, a reservoir of large extent in the vicinity of Rochester, would be desirable. It would probably be practicable to construct this in the bed of the Genesee itself, or that of any of its tributaries. There is, however, on the right bank of the Genesee in the neighborhood of Rochester, an opportunity of constructing a reservoir with great facility. The canal, after proceeding on a level for a mile and three-eights, to the east of Rochester, begins to descend. The descent is effected by five locks having an aggregate fall of thirty-seven feet, within a distance of a mile and three quarters. For this distance the canal skirts a slope which extends gradually to the north-east. It is obvious to the most superficial inspection that a level line might be run to the north at a depth of thirty-seven feet below the surface of the water in the higher level of the canal, which would include a very large extent of ground. Any portion of this ground might, if surrounded by an embankment, receive water from the canal on the Rochester level, or from the Genesee river, at times of

flood. This might, in case of need, be drawn from it into the Pittsford level, and thence into those further to the east. A careful survey would be necessary to determine the best position for such a reservoir, in reference to the cost of land and convenience of filling and discharging it. A reservoir of a square mile or upwards might be readily marked out, and by forming the embankment of earth excavated from within the selected space it might be made to admit of an average drought of twenty-five feet of water, or even more. A reservoir thus formed, by embanking a level portion of ground on the margin of a stream, has great advantages in point of security from accident by flood, of ease of construction and probably even in cost, over those which are formed by dams across the channel of a stream. This reservoir according to the opinion of those best acquainted with the Genesee river, might be filled from it as late as the month of June, without interfering with the mills, and a considerable surplus may, whenever the trade is not brisk, be drawn from Lake Erie by the canal itself. As the trade is least active in the month of August, and does not begin to revive until September, there seems to be little doubt that the reservoir might be maintained full until the beginning of the driest season of the year, and if of sufficient size would not be exhausted before the setting in of the autumnal rains.

The construction of such a reservoir, if not sufficient of itself to insure the supply of she canal to the east of Rochester, must tend, in a very great degree to compensate for the difficulties which, under the most favorable views that can be taken of the case must attend the supply of the canal for the entire distance of 122 miles from Lockport. A reservoir on the Valley of the Oak orchard creek, receiving water from the Tonawanda has been spoken of as essential to one part of the plan of canal.

According to the report of Mr. Barrett this may be made to include a thousand acres, and the streams, besides a great surplus in times of flood, furnish in the greatest droughts 1400 cubic feet per minute. It is also stated by Mr. Barnett that another reservoir of about 200 acres might be constructed on a stream which is sufficient to replenish it,

13. The dimensions which it is proposed to give to the canal at Rochester are larger than are absolutely necessary for a canal whose locks have a breadth of 16 feet. The breadth at bottom might be reduced to 32 feet, and that at top to 60 feet, without becoming unfit for the purposes of an easy navigation. It might therefore be expedient to give to the surface of the canal from Pittsford to Lockville, a distance of 25 miles, a breadth at the surface of 65 feet; and from the latter place to the Cayuga marshes, a breadth of no more than 60 feet. The latter breadth is as great in proportion to the width of the lock gates as is given in the practice of European engineers. It would appear to be expedient to give the longer levels a slight slope, say half an inch per mile. In the shorter levels, the flushes arising from lockage will give a sufficient velocity.

In order to insure that the canal may be fed from lake Erie to the

Cayuga level, probably by water from the lake, and certainly without the necessity of drawing upon the Genesee river in times of drought, it will appear from what has been stated that certain plans are important and absolutely necessary.

In conclusion, it will appear that the measures proposing for attaining the object of feeding the Erie canal from the lake, may be divided into two classes, one of which has reference to the management of the canal, the other to its structure. In respect to management, the most important points are, that the grass which grows in such quantities at the western extremity of the canal should be cut or destroyed, that the water which enters the Rochester level at Lockport in waves and flushes shall be retained in the canal until it has set the body of water in motion, and that if it should be absolutely necessary, although it is hoped there will be but rarely need, to introduce water from the Genesee river, it should be done in such quantity as will not raise the level, and thus interrupt the flow of water from Lockport.

Among the changes in the structure it is proposed, after attaining as great a degree of slope for the bed of the canal as can be reached without material injury to the towns on the route, to insure the conveyance of the quantity of water estimated to be necessary, by giving to the cross section of the canal, large dimensions in the neighborhood of Lockport, and lessening them in proportion to the expenditure of water on the way; to accelerate the flow after the last supply of water is admitted, by making a gradual diminution in the depth and thus increasing the slope of the surface, to prevent the filling in of earth and the filling up of the angles of the bed by amendments in the shape of the section, and the introduction of berms and counter-ditches; finally, as one of the most important features, it is proposed to bring in the aid of reservoirs intermediate between lake Erie and the Cayuga level. Of these, the one most essential to the regular working of the canal should be placed on the east bank of the Genesee at Rochester.

James Renwick.

We conclude in this number the report of Prof. Renwick, which was made at the request of the citizens of Rochester. Although a matter of apparently local interest, its immediate connection with the question of enlargement, cannot fail to give it interest. We believe the other reports on the same subject have not yet been published.

By an oversight, the article in our last number on Compressed Peat, did not receive credit as having been taken from the "American Repertory."

Owing to circumstances beyond our control, the last number of the Journal was not out on the day of publication. A recurrence of this will be prevented and the numbers punctually delivered when due.

New apparatus for heating blast for furnaces.—Mr. Lyman is engaged in constructing a new apparatus for heating the blast at his furnace, on the island, which we are assured, if it succeeds, (and the inventor has no doubt of it,) will be far superior to any thing of the kind now in use in this country or in Europe. Its superiority consists in always keeping the blast heated to a proper degree, increase of quantity, its application, and its economy, producing a saving of at least *one dollar* in the hot blast on every ton of iron made. As soon as it is tried we will furnish our readers with a more particular description.—*Miner's Journal.*

Unprecedented Despatch.—As an instance of the hitherto unequalled rapidity of communication between England and the United States, may be mentioned the circumstance that boys were sellling in our streets, on Saturday *morning* last, London papers of Saturday *evening*, Oct. 3d, received *via Liverpool*, being less than fourteen days from the time they were issued from the London press.—*Bost. Trans.*

Steam.—Lieutenant Janvier, of the French Navy is said to have discovered the means of getting up the steam of engines with such rapidity, that in ten minutes from the first lighting of the fire, and although the water in the boiler be quite cold, a vessel may be set in motion. This is, it is added, to be accomplished without any additional apparatus, and very little expense.

The receipts of the Liverpool and Manchester Railroad for the last six months amounted to 126,474*l*; the expenses to 67,003*l*, and the net profits to 59,471*l*. There was a previous surplus of 10,784*l*. A dividend of 5 per cent. was declared, amounting to 60,445*l*, leaving a balance of 9,809*l* to the to the credit of the next half-yearly account.

ON THE STEAM-ENGINE.

(Continued from p. 215.)

Having in our former papers ascertained the true constitution of steam, we shall henceforward be enabled to apply it in the best manner to produce motive power, as it evidently ought to be applied: comparing and correctly distinguishing its effects within the different kinds of engines in which it has been usually employed, namely, *low-pressure engines*, or those in which the piston is uniformly impelled the whole stroke by steam little exceeding in density the atmosphere, while resistance is removed from the opposite side of the piston by condensation of the steam; *high-pressure engines*, or those where the piston is driven with a uniform force the whole stroke, by steam of much greater density than the atmosphere, the opposite side of the piston being relieved by the steam escaping without condensation; and *expensive engines*, or those in which the piston is impelled some distinct part of the stroke by expanding steam alone.

If we thus far extend our views, the general and proportional efficiency of steam within engines will be fully exhibited, and the best method of applying it will thence become so very apparent, that the methods commonly preferred and practiced will appear in general as strangely erroneous as they are alike extensively and deeply injurious to many important and increasing interests.

If in a high-pressure engine, (which we shall denominate A for the sake of future reference) we employ steam of the density of four atmospheres, or with a pressure of 60 lbs. per square inch, its effective force upon the piston will be three atmospheres only; because the steam, in its exit from the cylinder, re-acts against the piston with a force of one atmosphere:

hence the effective pressure of the steam is reduced to 45 lbs. per square inch.

If in a low-pressure engine, (which we shall call B) we employ steam of the density of one atmosphere, or with a pressure of 15 lbs. per square inch, the same absolute quantities of water and heat that were employed to form steam of 60 lbs. per square inch in the preceding high-pressure engine, will supply a low-pressure engine of four times the capacity with steam of 15 lbs. per square inch; and as the piston will be resisted by the reaction of steam of about 1 lb. per square inch in the vacuum so called, the actual effective preesure of the steam is reduced to 14 lbs. per square inch; but as the area of the piston is four times as large as in the high-pressure engine, so the effective force of the steam upon it is as proportionally greater as 56 to 45; and the low-pressure engine would be of course the most powerful in that proportion, were it not that in a low-pressure engine an allowance must be made for an additional load upon the engine, resulting in the power employed in working the air and hot-water eduction pump, and in working the cold-water pump. For this reason, the aforesaid balance in favor of B will be varied with local circumstances, and be considerably reduced in large engines, while in small ones it may be annihilated.

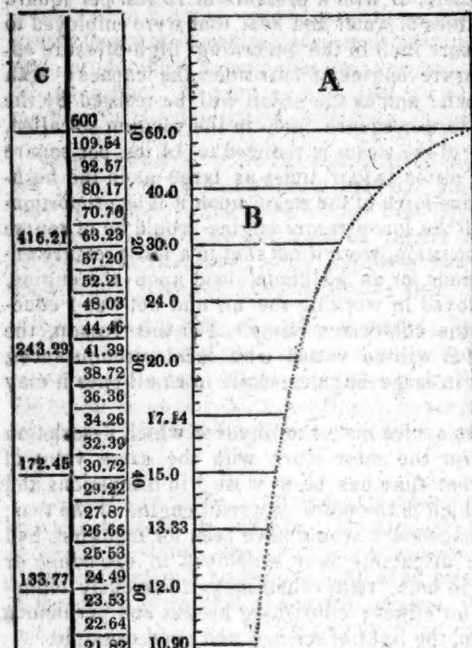
Hence, then, it is oftentimes a nice matter to discover which description of engine, A or B, will perform the most work with the same value of steam; and again we see what time has been wasted in discussions and fruitless disputations as to which is the more powerful engine of the two; and how much more advantageous it would have been for mankind, had the talents and leisure of the disputants been employed in extending or perfecting the improvements in both, rather than in pertinaciously claiming unwarranted superiority for either; nourishing useless and pernicious prejudices; neglecting reason, the light of science, and good example.

How far a neglect of these has been injurious will be apparent, if we observe that high steam, when expanded, is not lost, but merely becomes low steam; and that low steam, propelled from high-pressure engines, though so generally and carelessly wasted, still remains as powerful and as valuable as was the high steam employed, were it but properly applied in a suitable engine. It is evident from this that steam which has propelled any high-pressure engine, as A, may be just as advantageously again employed to propel one of low-pressure, as B; equal in power to A, because the area of B may always be so proportioned to the density of the steam in A as to secure its full efficiency. Hence, again, the converse follows: the steam required for a low-pressure engine may be generated of greater density, and first used to propel a high-pressure engine previous to its employment in one of low-pressure.

Now, as steam can be practically employed twice in succession, should we choose, it can thus be always doubled in value, for two results can be obtained with one expense, and a great economy be thus effected wherever a sufficient supply of cold water can be obtained for condensation of steam, when again employed in a low-pressure engine.

What a complete contradiction is produced by this valuable result to overthrow all Mr. Palmer's assertions! showing, as it does, that the powers of all existing low-pressure and high-pressure engines may be doubled without expense, his very great authority against it notwithstanding. What a splendid lesson does it furnish to the confused, dull and tiresome advocates of the present ineffective low or high-pressure engines, in which the mere successive employment of steam alone is here undeniably shown to produce, in the joint use of those engines, double the power that can be produced by

them if but singly employed as at present, and which employment is so advocated and so lauded, and in such a haughty tone of defiance, by Mr. Palmer, as perfectly unsurpassable!



The actual power to be gained by the expansion of steam within a heated cylinder, maintained at a constant temperature, is shown in the annexed diagram and table, wherein the space A represents the quantity of high steam expanded; the space B, inclosed and bounded by the parabolic curve represents the proportional additional power gained by the expansion of the steam in A, through the respective portions of B, in which the ordinates represent the decreased density of the expanded steam, corresponding with and consequent upon its expansion.

The table C shows the calculated value of each area of the fifth of a volume of the high steam employed, and represents the actual gain, which may be thus ascertained by inspection.

For example: Assuming the value of the high steam as 600, and when an equal volume of the steam has been cut off, as at half stroke, the gain is 401.23; when cut off at one-third stroke, the gain is 659.50; and so tabulated for any portion, to one-tenth of the stroke.

In the diagram, the high steam admitted to be expanded is assumed of the density of 60 pounds per square inch; but the proportional gain, by the expansion of steam of any other density, may be obtained from the table by simple proportion, because the expansive value of steam is a constant proportional quantity. Thus: If the value of steam of 85 lbs. per sq. inch be required when twice expanded; then, as 60 lbs. is to the tabular value of 659.50, so is 85 lbs. to $93.44 \times 85 = 178.44$; the value required.

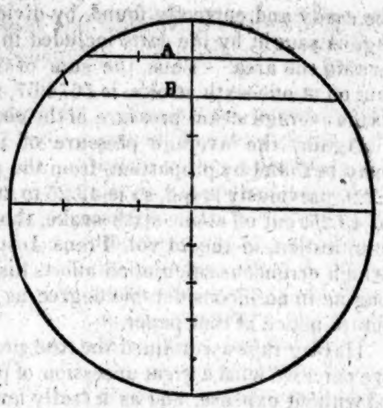
Again: the average steam pressure of any area of the table C may also

be easily and correctly found, by dividing the sum of the area whose average is sought by the parts included in the centisimal scale of the diagram within the area. Thus, the sum of the area of steam of 60 lbs. per inch, cut off at one-sixth stroke, is 1674.67, and divided by 60 parts, the sum 27.9 is the average steam pressure of the section sought.

Again: the average pressure of incipient steam of any other density may be found by proportion, from the previous process. Thus, as 60 is to 27.9, previously found, so is 43.25 to 20.11, the true value of incipient steam of 43.25, cut off at one-sixth stroke, though given in Mr. Wickstead's communication, in the 2d vol. Trans. Inst. Civil Engineers, as 17.66 only, and which erroneous calculation affects his description of the value of a Cornish engine in no inconsiderable degree, as we shall more particularly state in a future notice of that paper.

Having thus ascertained the true proportional value of expanded steam, we perceive what a great accession of power may seemingly be thus obtained without expense, and as it really may be, to a very great extent, in the pumping engine; because steam, however much expanded therein, provided its elasticity still continues to exert a greater force than all the friction of the engine and of the pumping machinery united, the motive power of the steam still remains available, which in this kind of engine is appended to one end of a lever beam, from the opposite end of which the load is suspended. Any power thus applied acts with its full effect at all parts of the stroke, as the load is always reacting with a uniform leverage, just as a weight in one scale acts on the weight in the opposite scale of a common balance: hence, the full effect of steam decreasing in intensity is limited alone by the friction of the engine and machinery. But in rotary or crank engines, a much earlier limit obtains, from the nature of the crank itself, combined with the rapid decrease of the expanding force of steam; and this limit has been found of so much actual consequence in these engines as to have caused many engineers to hazard the assertion that the expansive force of steam could not be advantageously employed therein. And the assertion is not made without some show of reason; because this expansive force cannot be practically employed to either the same extent or to the same advantage, in rotary as in pumping engines; yet as it can be employed in them to a highly useful extent, it is very desirable and very important also, to ascertain with some tolerable precision what that extent actually is.

We shall now endeavor to show by the annexed diagram, with the aid of our former one, why the power of expanding steam cannot be employed as effectively in rotary as in pumping engines, and what degree of power can be obtained in the former; and though our proofs, to be practical and popular, will not be strictly precise, yet they will be sufficiently so for the sole purpose for which they are here produced, to explain the useful and important facts under immediate consideration.



Let the path of the crank pin be represented by the circle in the diagram, and the descent of the steam-piston by the perpendicular diameter divided into 10 equal parts. Let us now suppose high steam admitted on the piston, to be cut off at a small part of the stroke, as recommended by non-practical theoretic writers.—We assume one-tenth of the stroke, in accordance with such recommendations, and as conveniently affording chords of whole numbers.

Now, the load of a paddle-wheel, or of any other machinery driven by a crank engine, being constant, may be represented by the radius of the circle=5; and during the descent of the piston through one-tenth of the stroke, the average effective leverage of the crank has been just half that of the semichord A=3: hence, the effective leverage of the crank has been, during this portion of the stroke,=1.5, or three-tenths of the radius only; it is evident the value of this, the most effective part of the motive power, the force of the unexpanded high steam, is reduced in the ratio of 10 to 3.

The semichord B being=4, during the descent of the piston the next one-tenth part of the stroke, it is evident the leverage of the expanding steam is as 3.5 to 5.0=the radius; and the value of this, the most effective portion of the expanding steam, is reduced in the proportion of 10 to 7.

In this great loss of power, or little effect from the small leverage of the upper portion of the crank during the rapid expenditure of the most effective portion of the steam, exhibited in the upper part of the diagram and parabolic curve, we may perceive sufficient cause for the great difference that is found between practice and the assumptions of theoretical writers.

We shall now attempt an explanation of facts, as fully as we can, as we shall at a future period find it exceedingly essential, and involving consequences of the first importance in our view of the future and full improvement of the steam-engine. Our observations on this particular subject are deduced from the long by-gone experience of more than twelve years, in working a powerful condensing, double-acting crank engine, impelled by expansive high steam, and constructed on purpose to test, and in hope of realizing, our expectations and views, which in a great measure resembled those now or recently held by Professor Renwick; as well as other essential improvements of the steam-engine, which will be fully explained hereafter, as they have proved of singular utility in steam navigation, and will contribute much to the future general improvement of the steam-engine. The engine, and machinery attached to it, afforded the fullest opportunity for correctly investigating the amount of work done at different times and under different circumstances.

For a considerable period, the high steam was cut off by different timed movements of the slide, effected by cam wheels, closing the induction steam passages completely, at one half, one-third, one-fourth, one-fifth of the stroke, the eduction passages for steam being open nearly the whole stroke; when it soon appeared that one-fifth was useless, one-half and one-fourth each much less useful than one third, which was very superior to all others, and very effective.

Subsequently the slide was operated the whole stroke, by a common ec-

centric movement, and the high steam cut off by a small expansion valve; and again in these altered circumstances, as far as could ever be observed in numerous trials, the maximum effect of the steam producing the greatest efficiency of engine was obtained by cutting off the steam at one-third the stroke. Now, in both cases the really true internal abscission, had an indicator been applied to test it, was probably a little earlier than one-third; and as the motion of the steam-piston was at that portion of the stroke accelerating, and the motion of the slide retarding, the steam was somewhat expanded, (or wiredrawn) as the slide or valve closed: hence, then, a small portion of the estimated quantity of high steam may have been, and probably was deficient.

With this small reservation, the cutting off steam at one-third was found very superior to all other proportions for efficiency and economy; and whenever we have since had opportunities of comparing the work performed by a crank engine with the period for cutting off the high steam, we have found our former experience confirmed, and which, it may be seen, is also equally confirmed by the Cornish practice, where the happy application of expansive steam in pumping engines has been unsurpassed, and where the same talent and persevering industry has been employed to perfect the crank engine.

It appears in Mr. Wickstead's paper, in the 2d vol. Trans. of Inst. Civil Engineers, page 65, in a very improved double crank engine, for breaking ores at the Tincroft mine, the steam was cut off at two-fifths the down stroke, and at one-third the up stroke, and the duty exceeded 56,000,000 lbs. lifted one foot high, with one bushel coals. Now, as this duty of 56,000,000 lbs. performed by a stamping or rotary engine, impelled by expansive steam, is hailed as an extraordinary performance, and in the same paper in which Mr. Wickstead's reports a pumping engine to have performed nearly 118,000,000 lbs. duty, or more than double the duty of the best Cornish crank engine, the fullest confirmation is thus given of the great loss of power, or rather of the lesser power of expansive steam in crank engines—the causes and limits of which, hitherto neglected, we have endeavored to explain.

It may be as well here to observe, that in our engine the slide and valve were each so accurately fitted as effectually to close the passage for high steam at the periods stated; and this observation becomes necessary, from the different and common practice here of employing that ineffective contrivance, the throttle valve, for that purpose, which by only partially closing the passage for high steam, allows some to pass even at first, but admits a considerable quantity to pass towards the termination of the stroke. From the general imperfect nature of these valves, and their coarse construction, the steam becoming much expanded within the cylinder, on one side of the throttle valve, and remaining of great density on the other side, rushes through it with immense velocity towards the termination of the stroke, and the effect of all steam thus admitted to pass, it is well known is much misapplied.

Returning from this digression to our subject—the value of expansive steam—which having been found of full efficiency when cut off at one-third stroke, we are able to ascertain correctly, by the aid of our table, the real gain by expansion, and thus to rightly distinguish between the absurd *no gain* of Mr. Palmer, and the equally enormous and unwarranted assumptions of Prof. Renwick; and we thus are reasonably and satisfactorily assured that the gain by this process alone really equals or rather exceeds the original value of high steam, when used unexpansively in crank engines, while the steam still remains just as applicable to any other useful

purpose, as of heating, drying, warming, or ventilating, as before, still remaining the same definite compound of water and of heat, of enlarged volume only—still unaltered in its chemical constitution; and still as efficient for propelling a low-pressure steam-engine as steam of equal density generated for that particular purpose alone.

We may sum up these remarks, intended for illustration only, by observing:—1. If from a given quantity of high steam a proportionate power is obtained, as commonly it is in this country in an unexpansive high-pressure engine, double that power may be obtained from the same steam in an expansive engine; and a further equal increase of power may be obtained from employing the same steam, subsequently to propel a low-pressure engine; so that, in general terms, we may double the power of the high steam by using it expansively, and treble its power by again using it in a condensing engine.—2. The converse of these propositions must be equally true—that steam, as commonly employed in low-pressure English engines, and as advocated by Mr. Palmer as unsurpassable, may be first previously employed to propel a high pressure engine, or an expansive high-pressure engine, and thus made to furnish an equal power, or a double power, previous to again employing as profitably the same steam as in Mr. Palmer's inimitable. Thus, probably, may almost every factory engine in existence, every locomotive that runs, or steamboat that floats, be improved in one or more of those important particulars—either in economy, power, or safety.

That much more than all this has been done in the Cornish pumping engines, is well known, and we have shown why it can be so done; and in our next we will endeavor, by an analysis of the properties of the pumping engines, to show why a much greater duty may be reasonably expected from them than has yet been reported, and extending our remarks to the general employment of expansive engines in the steamers of this section of the United States, we shall show that these engines are as unaccountably avoided, by the unwarranted prejudices of the English engineers, as they are here rendered unnecessarily hazardous.

From the positive and undeniable facts brought forward, each susceptible of easy and distinct proof, what a mean view must we not take of the inefficient, extravagant, and dangerous modes commonly employed for obtaining motive power from steam, merely from a disregard, amounting to almost total neglect, of contingent advantages, that would as extensively benefit society as greatly add to the honor of the national character! For, after all these separate, distinct and repeated uses of steam, even after it has been condensed in a low-pressure engine, no portion of the heat has even then become latent, or hidden, or lost, but still remains sensible and apparent—is still to be all found in the warm or hot water flowing from the engine; and what is of more consequence, may still be again employed to great advantage and considerable profit in cities or other populous places, where the now extended use of steam might and ought to be employed to procure inestimable advantages to society, by furnishing unlimited means of cleanliness, with increased comfort and health, by an abundant, constant supply of tepid and warm baths, at such a trifling expense as would secure their free use to the whole population. Thus all classes, however humble, might enjoy this comfort, pleasure, and inexpensive luxury, at present unknown even to the most opulent, and from which they are alone debarred by penury of thought.—*American Repertory.*

Steamboat Challenge for 1000 *Guineas.*—The patentee of the screw-propeller invention now in operation in the *Archimedes* has published a challenge for the above sum to any steam vessel worked by paddle wheels,

and of the same steam power, tonnage and draft as the *Archimedes.* The trial to take place in the open seas, over the distance of 400 to 500 miles, before the 15th October. This challenge does not extend to vessels with high pressure engines. The name and address of the challenger are F. P. Smith, Wade's Terrace, London.

RAILROADS IN THE UNITED STATES.—By Chevalier De Gerstner.

RAILROADS IN THE STATE OF PENNSYLVANIA.

The first railroad in America was constructed in Pennsylvania, and the same State has at present the greatest extent of railroads in operation. With the exception of only two lines, all have been constructed by private companies. Some of those established at an early period were designed exclusively for the transportation of coal from the mines to the place of their transhipment. For the construction of these roads little regard was paid to the grades and curvatures; and inclined planes were frequently resorted to. The other railroad lines, generally of a much greater length, are used for the transportation of passengers and freight. The manner of construction of the different railroads in this State is very various, and it is of great interest to follow all the improvements made in this respect since the construction of the Mauch Chunk railroad, finished in 1827, up to the present time, when all the experience acquired during 13 years is brought into application; on the Reading railroad, for instance. With the exception of some of the oldest coal railroads, the tracks have an uniform width of 4 feet 8½ inches, the same as was adopted in England. The superstructure is generally of wood—flat bars upon continuous bearings, or heavy T rails upon wooden cross ties. As motive power, stationary and locomotive steam engines, horses and mules, and gravity, are used.

The following table contains a list of all the railroads in the State of Pennsylvania either completed or in progress of construction, in 1839, and has been prepared after a personal examination of the different works:—

1. In the whole there are 40 different railroad lines in the State of Pennsylvania, 2 of which were constructed by the State, and 38 by private companies. The longest continuous line of railroad now in operation in the State, is that from Philadelphia to Greencastle, a distance of 163 miles; and the total length of railroads, which were in use at the close of 1839, is 576½ miles; there were besides 161¼ miles nearly completed, and 112¼ miles to be constructed, making the total length of all the railroads in the State, when completed, equal to 850¼ miles.

2. The number of locomotive engines employed for the transportation of passengers and freight in the State of Pennsylvania is 114; they run upon 16 railroads with an aggregate length (in operation) of 485 miles, being 1 locomotive engine for 4¼ miles of railroad. In some of these railroads stationary steam power is also applied.

3. The above statement contains the amounts already expended on 26 railroads, and their ultimate total cost; of the other roads the exact amounts have not been ascertained. If we compare the length of these 26 railroads, which is 686¼ miles, with their total cost of $19.867,450, we find the average cost per mile $28, 950. At a fair estimation, the amount already expended on those works, not comprised in the above 26, and being 164 miles in extent may be put down at $2,410,000, and their ultimate cost at $3,200,000, we then have:

Total amount expended for railroads in Pennsylvania,	$18.050.450
Amount yet to be expended on works under construction,	5,017,000
Total cost of all the railroads, when completed,	$23,067,450
And the average cost per mile, " "	27,130

RAILROADS COMPLETED AND IN PROGRESS IN THE STATE OF PENNSYLVANIA.

No.	Name of Railroad.	From and to where.	Opened. Year.	Opened. Miles.	No. of miles. Besides graded.	No. of miles. Not yet c'nstr'd.	Total length of road.	Weight or dimensions of iron rails or bars	Motive power used.	Amount of capital already expended	Amount wanted for completion.	Total cost of road.	Cost per mile.
1	Philade'phia & Colum.	Philadelphia to Columbia.	1834	82			82	41 lbs.	36 locomot's	4,000,000		4,000,000	48,780
2	Alleghany Portage,	Johnstown to Hollidaysburg.	1834	36$\frac{2}{3}$			36$\frac{2}{3}$	39$\frac{1}{2}$ lbs.	17 "	1,850,000		1,850,000	50,450
3	West Chester,	Columb. and Phil. R. R. to W. Chester.	1834	9			9	2$\frac{1}{4}\times\frac{5}{8}$	horses.	90,000		90,000	10,000
4	Valley,	Columbia and Phild's R. R. to Norristown.			10	10$\frac{1}{4}$	20$\frac{1}{4}$						
5 6	Phild'a., Germantown, Norristown,	Philadelphia to Germantown and Norristown.	1837	20$\frac{1}{4}$			20$\frac{1}{4}$	40 lbs.	8 locomot's				
7	Philadelphia & Reading	Philadelphia to Mt. Carbon.	1839	54$\frac{1}{2}$	15	32$\frac{1}{2}$	102	45 lbs.	7 "	2,976,000	1,614,000	4,590,000	45.000
8	Philadelphia & Trenton,	Philadelphia to Trenton.	1833	30			30	2$\frac{1}{4}\times\frac{5}{8}$	5 "	400,000		400,000	13 333
9	Philad. & Wilmington,*	Philadelphia to Wilmington.		28			28	2$\frac{1}{4}\times\frac{5}{8}$	4 "	500 000		500.000	17.857
10	Harrisburg & Lancaster	Harrisburg to Lancaster.	1837	36			36	2$\frac{1}{4}\times\frac{5}{8}$	8 "	860,000		860,000	23,900
11	Cumberland Valley,	Harrisburg to Chambersburg.		46			46	2$\frac{1}{4}\times\frac{5}{8}$	8 "				
	Franklin,	Chambersburg to Williamsport	1839	10$\frac{1}{2}$	6	7$\frac{1}{2}$	24		1 "				
12	York and Wrightsville,	York to Wrightsville.			13		13	58 lbs.					
13	Mauch Chunck,	Mauch Chunck to Coal Mines.	1827	9			9	2$\times\frac{1}{2}$	mules	100,000		100,000	11,110
14	Room Run,	Near Mauch Chunk to Mines.	1823	5			5	2$\times\frac{1}{2}$	mules	150, 00		150,000	30,000
15	Beaver Meadow,	Beaver Meadow to Parryville.	1836	26			26	2$\frac{1}{4}\times\frac{5}{8}$	6 locomot's	360,000		360,000	13,846
16	Hazleton Branch,	Hazleton to Beaver Mead. RR.	1838	10			10	2$\frac{1}{4}\times\frac{5}{8}$	3 "	120,000		120,000	12,000
17	Sugar Loaf Summit,	Branches to Beaver Meadow.	1839	2	2		4	2$\frac{1}{4}\times\frac{5}{8}$	1 "	30,000	10,000	40,000	10,000
18	Buck Mountain,	Buck Mountain Coal Mines to Lehigh.			4$\frac{1}{3}$		4$\frac{1}{3}$	38 lbs.		100,000		100,000	23,077
19	Susquehanna & Lehigh,	Wilkesbarre to Whitehaven.			20$\frac{1}{2}$		20$\frac{1}{2}$	57 lbs.		600,000	400,000	1,000.000	48,785
20	Little Schuylkill,	Port Clinton to Tamaqua.	1831	22		7	29	2$\times$0.44	5 locomot's	400,000	100,000	500,000	17,241

*The Philadelphia and Wilmington railroad now forms a part of the Philadelphia, Wilmington and Baltimore railroad; the whole of which has cost $4,400,000.

RAILROADS COMPLETED AND IN PROGRESS IN THE STATE OF PENNSYLVANIA.—CONTINUED.

No.	Name of railroad.	From and to where.	Opened. Year.	Opened. Miles.	No. of miles. Besides graded.	No. of miles. Not yet constr'd	Total length of road.	Weight or dimensions of iron rails or bars	Motive power used.	Amount of capital already expended.	Amount wanted for completion.	Total cost of road.	Cost per mile.
21	Little Schuyl. and Sus.	Catawissa to Little Schuy. RR.			39		39	50 lbs.					
22	Beaver Meadow Extension.	Little Schuylkill & S. R. R. to Beaver Meadow R. R.			12		12	50 lbs.		850,000	1,000,000	1,850,000	36,275
23	Schuylkill Valley,	Port Carbon to Tuscarora.	1830	10			10	$1\frac{1}{2} \times \frac{3}{8}$	horses	65,000		65,000	6,500
24	Mill Creek,	Port Carbon to Coal Mines.	1830	5			5	$1\frac{1}{2} \times \frac{3}{8}$	horses	45,000		45,000	9,000
25	Branches to both,	From different Mines.		12			12	$1\frac{1}{2} \times \frac{3}{8}$	horses	54,000		54,000	4,500
26	Mount Carbon,	Mount Carbon to Minehill.	1831	7			7	$2\frac{1}{4} \times \frac{5}{8}$	horses	118,000		118,000	16,854
27	West Branch,	Schuylkill Haven to Minehill and branches.	1831	18			18	$7\frac{1}{2}$&35 lbs.	horses	315,450		315,450	17,525
28	Pottsville and Danville,	Pottsville to Sunbury.	1838	$29\frac{1}{2}$	3	10	$42\frac{1}{2}$	$2 \times \frac{1}{2}$&$2\frac{1}{4} \times \frac{5}{8}$	2 locomot's	670,000	200,000	870,000	20,470
29	Williamsport & Elmira,	Williamsport to Pa. *State* line.	1839	25	1	41	67	$2\frac{1}{4} \times \frac{3}{4}$	1 "	437,000	903,000	1,340,000	20,000
30	Blossburg & Corning,	Blossburg to Pa. *State* line.			$25\frac{3}{4}$		$25\frac{3}{4}$	$2\frac{1}{4} \times \frac{3}{4}$	2 "	250,000		250,000	9,709
31	Carbondale,	Carbondale to Honesdale.	1829	$16\frac{1}{2}$			$16\frac{1}{2}$	$1\frac{1}{2} \times \frac{1}{2}$&$2\frac{1}{4} \times \frac{1}{2}$	horses and stat'n'ry eng	300,000		300,000	18,182
32	Pine Grove,	Union Canal to Coal Mines.	1830	4			4		horses				
33	Lykens Valley,	Millersburg to Bear Gap Mines	1830	$16\frac{1}{2}$			$16\frac{1}{2}$		horses				
34	Bear Creek,	Pottsville & Danville R. R. to Coal Mines.			2	2	4						
35	West Philadelphia,	Philad'a. & Columbia R. R. to river *Schuylkill*.			8	2	10						
39	Philadelphia,*	Within the city of Philad'a.		6			6	$2\frac{1}{4} \times \frac{5}{8}$	horses				
				$576\frac{1}{2}$	$161\frac{1}{2}$	$112\frac{1}{4}$	$850\frac{1}{2}$		114 l'com't's				

*The railroads in Philadelphia are:—the City railroad, 2 1-4 miles; N. Liberties and Penn Township, 1 1-4 miles; Southwark railroad, with branch, 2 1-2 miles

3.104.400
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AN ESSAY ON THE BOILERS OF STEAM ENGINES. By A. Armstrong, Civil Engineer.

EXPLOSIONS.

Explosions of steam boilers have occurred so frequently of late years, and have been attended with such disastrous consequences, particularly when they have happened in steam packets, that the subject calls loudly for legislative interference. In America, where the explosions of steam packet boilers have been more frequent, from the general use of high pressure engines, some legislative restrictions have been recently adopted, founded upon a set of very ably conducted experiments, peculiarly adapted to the practice in that country. A few points, however, remain open to investigation; and as the subject must be one of intense interest to all those who, with a laudable anxiety for improvement, combine a proper regard for the welfare of their fellow-creature, we shall examine as much of it as regards the safety of the ordinary low pressure boiler, as generally used, and which comes more particularly within the scope of this essay.

It is freqnently observed that a boiler of about thirty horse power will require from a ton to a ton and a half of coal extra, during the first day after it is cleaned out. This arises from the practice of cleaning out the boilers, as well as the flues, by means of human beings, instead of mechanical contrivances, although the latter are easily available for both purposes. The means of effecting the former have been already described, and have been adopted to a considerable extent; but we have not such sanguine expectations that similar means of cleaning out the flues will be so readily adopted, the pecuniary advantage resulting therefrom not being so apparent as in the other case,

The ordinary practice in Manchester is to clean out the boilers once a month, and to clean out the flues at the same time; preparatory to which the boilers mostly require filling once or twice with cold water, to cool them: consequently, in getting up the steam the next morning, there is not only all the extra fuel required for heating the comparatively cold water, but quite as much more is required to bring up the mass of brick-work, and all the adjacent parts, to their former temperature. It is of little or no avail that there may be a spare boiler kept, for the cooling of it is still necessary, either by standing a week, or in one way or other, and of course the loss is the same.

It generally happens, that the spare boiler, if there be one, stands immediately adjoining those that are constantly at work, and the heat from the adjacent boilers and brick-work renders it quite impossible to clean out the flues without an amount of individual suffering which few people have any idea of. The ordinary climbing boys are not generally employed to sweep the flues of a steam-engine boiler in a factory; a strong man usually is required for the purpose. Quite a different sort of manual process is necessary than that used for sweeping a common house chimney; indeed the latter must be, comparatively, a pleasant occupation. In the former case the man has to *worm* himself through the flues, in a horizontal position, pushing before him the contents of the flue, or "flue dust" as it is called; which is not soot, but a heavy kind of deposit, consisting of very fine ashes, being the burnt earthy particles of the fuel, which are fine enough to be carried forward with the draught. The most expert hands at this kind of work are generally natives of the sister isle, who are ever ready, for the smallest pittance, to undertake this drudgery, and with whose labor, as to value (at least as to price) it is in vain to attempt competition with machinery. It is from the above mentioned class of men that the stokers or firemen for the steam engines in Manchester and Liverpool are generally ob-

tained; and certainly there are none so capable of being made good firemen as intelligent Irish laborers, especially if they have been previously good spademen.

The foregoing may seem to bear only very remotely on the question of explosions, but it is rendered necessary in order the better to elucidate a view of the subject, according to which it is believed we may account for the great majority of the explosions which have occurred in factories and other large works.

It is a fact very well known, that many of the explosions of steam boilers, which have occurred of late years in the factories in this district, have taken place on Monday mornings, a little before six o'clock, and it is generally believed that the whole of those have done so, whose causes have not been hitherto clearly ascertained. Now if we take into consideration that the fireman have generally the charge of cleaning out the boilers and flues, and that along with this they are commonly charged not to be seen doing their work on a Sunday; then, bearing in mind what we have stated, of the difficult nature of the operation, rendered still more difficult when it is obliged to be done on a week day, when the fires are burning in the adjoining furnaces, perhaps one on each side, merely separated by a thin brick wall, adding to this the necessity of keeping the damper of the spare boiler closed, otherwise the fires under the other boilers do not burn properly,—this work has, on all these accounts, generally become a night job, consequently there can be little superintendence of either masters or managers, and therefore it is not to be wondered at if the boilers and flues very frequently go without any cleaning at all.

In illustration of the usual routine of the fireman's business, we may state that it sometimes goes on this way:—Suppose the getting up of the steam to require three or four hundred-weight of coal extra on the Monday morning of the second week after the boiler and flues have been cleaned; the Monday morning after that it will require five or six hundred-weight, and thus it will go on requiring a few hundred-weight more at the commencement of each week than in the preceding one, until the boiler goes several weeks without being let off—the consumption of fuel going on all the while in an increasing ratio, along with an increased difficulty of raising the steam, until, at last, the poor stoker sometimes finds that he cannot raise the steam at all. This is, of course, a consummation that rarely takes place in regular factories, where there are seldom fewer than two or three boilers, and therefore the steam which cannot be obtained from one boiler must be had from another; but at collieries, and in many country places, where there may be only one boiler to an engine, it occasionally occurs. Now, the consequence in the majority of those cases, is generally of little account, excepting on the score of economy, for the boiler has only to be let off and re-filled, and all is right again; but it is altogether very different at a factory, where there may be a good chimney and a strong draught, and also several hundred workpeople depending upon the engine starting at the proper time--in such a case, as it is sometimes significantly expressed by the enginemen, there must be steam or else a *blow-up* of one kind or other.

Most people are aware of the rage for building very large factory chimneys, during the last few years, and as they are usually built much larger at first than the wants of the factory require, there is always a surplus draught, which, by setting the main damper wide open, can be taken advantage of to any extent, and in many cases to cause an intensity of heat almost equal to that in a blast furuace. Where this surplus draught is easily available, the fireman has little to do but open his dampers, and the steam is got up in one half the time that it required formerly.

Whether the boiler is dirty, or has too much water in it, one consequence is the same, under ordinary circumstances, namely, a greater length of time is required for getting up the steam, and this necessarily requires the earlier attendance of the fireman. Now the fireman is not generally summoned at a certain hour like the regular mill hands, and if he can only contrive to get up the steam in sufficient time for the engine starting at the appointed minute, there is seldom any fault found; therefore any expedient which will enable him to prolong the period of his commencing work is not likely to be neglected, and such an expedient he has wherever there is a good draught.

It unfortunately happens that, in this matter, the apparent interests of the manufacturer and the real interests of humanity do not agree; for it has been incontestibly proved, that a strong draught is extremely favorable for saving fuel, as may be judged from the fact, that the time for getting up the steam has been in some instances reduced from upwards of an hour, to twenty or twenty-five minutes, and although the saving of coal has not been in any thing like that proportion, yet it has been very considerable.

Under similar circumstances to those just mentioned, there can be no doubt that a portion of the boiler bottom occasionally becomes nearly red hot, although this condition appears extremely inconsistent with the supposition that it is at the same time covered with water; yet we have been compelled to adopt this conclusion, from having had ocular demonstration of its possibility, as well as other reasons. We had frequently heard the fact stated by intelligent enginemen, and had more than once been called to witness it, although even then inclined to consider it a mistake, owing to the difficulty of ascertaining it clearly; for a slight approach to the incandescent state must be nearly invisible, owing to the strong glare of light from the furnace directly beneath, while any degree of heat much higher would be sure to weaken the iron so much as to cause the boiler bottom to give way.

In one instance, however, the rivet heads appeared to be approaching to a redness, and we immediately took care to ascertain that sufficient water was in the boiler. On returning to the furnace, we observed a circular space, of six or eight inches in diameter, in one of the plates over the middle of the fire, "drawn down" into a spherical segment, or swelling, of about two inches in depth, something similar in appearance to those formed on a smaller scale in glass blowing, but its further protrusion had evidently been checked by the sudden opening of the fire-door, and which no doubt prevented any serious consequence at the time. The boiler was a cylinder, of nearly six feet in diameter, and the pressure was about nine or ten pounds to the square inch. The occurrence took place just at the moment of the steam being sufficient to blow away at the safety valve, and a few minutes before the engine started. For a few days afterwards, this segmental protuberance was observed to increase gradually to a hemispherical shape, of three or four inches in depth, when it burst without doing any further damage than putting out the fire.

It is well known to engineers, that a similar bulging out of a portion of the bottoms of cylindrical boilers, when the fire-grate is placed too near, is a very common occurrence, and we have known boilers to work for several weeks, and even months, without bursting, after those swellings had been first formed. A precisely similar swelling to that above mentioned, took place a short time before, with a boiler of the same kind, at the same works. The chimney at these works was of an immense size, consequently the draught was extremely strong, and it was the boast of the engineer that he could, when he liked, have the steam up in a quarter of an hour,—

it ought to be added, that it was also the boast of his master that he could burn the worst possible kind of coal.

The probability of boiler bottoms sometimes approaching a red heat, receives a corroborative proof on examination of the iron plates, in many cases, where the boilers have bulged out in the manner we have been describing, and which exhibit an appearance, well known to boiler-makers by a peculiar color in the iron surrounding the part which has been red hot.

Whenever a boiler bottom is seen in this state, of course the only method of avoiding danger is to slack the fire immediately, by opening the fire-doors. But it frequently happens that the fireman thinks the boiler is empty, and, if he has an opportunity, he immediately lets into it a quantity of water, when the consequence uniformly is, that the boiler bursts instantly.

From what we have stated above as the common practice in the factory districts, we may conclude that the principal cause of boilers becoming unduly heated is undoubtedly, in a majority of cases, owing to the interposition of indurated, or encrusted earthy matter, between the heated iron and the water, and the manner in which those circumstances operate in producing an explosion appears to be as follows: we have before shown, (Art. 253,) that an internal coating of boiler scale is liable to crack and separate into large pieces, which are thrown off from the boiler bottom with a certain degree of violence, at some particular degree of temperature, depending upon the thickness of the scale and the kind of substance of which it is formed. This may account for some of those detonations, or reports, said to be heard immediately previous to explosions. It may be noted here, that the scale, when very thick, is always found to come off much easier, and is consequently detached by a lower temperature, than when it consists of merely a thin coating of carbonate or sulphate of lime; in the latter case it requires a much higher temperature, and only comes off in small patches of a few inches in diameter.

We may easily suppose, that by unduly heating the boiler, a large portion of scale may be suddenly detached, uncovering one or two plates, at a temperature something exceeding the *mamimum evaporating point*, which is well known to be considerably under the lowest red heat of iron (by the American experiments it is at about 400° Fah.). Then, the first effect produced will evidently be a certain amount of repulsion between the over-heated iron and the water, which may continue for several seconds, and perhaps for a few minutes: this may account for the sudden *decrease* in the supply of steam, which has frequently been observed for a few moments just before the explosion of a boiler has taken place.

The next effect must arise from a gradual diminution of temperature, during the same short space of time, in that part of the over-heated iron which is exposed to the water,—creating a contraction of the metal, increasing rapidly as the temperature approaches the evaporating point, and causing a corresponding strain upon the rivets in the boiler bottom. The direction of this strain may generally be traced on examining the bottom plates of any old boiler; it is always found to radiate in lines proceeding from that plate or part of the boiler bottom which has been most acted on by the fire, and is usually indicated by short cracks or rents between the rivet holes and the edges of the plates.

The next and concluding step, in case of the materials not being able to withstand the strain superinduced by the contracting metal, must be the sudden giving way of some bad seam of rivets, which the most nearly coincides with what would otherwise be the true line of fracture, and which may possibly be at some considerable distance from the plate which is the most heated; thereby giving the effect of a great leverage to the pressure

acting upon all that portion of the boiler bottom included within the actual line of fracture. Now the consequence is, not perhaps that this portion is blown out, as would most probably be the case with a cast iron boiler, but it will be bent or doubled back, the line of flexure running across the hottest or weakest part of the iron. A rupture being thus effected, an explosion is inevitable, if the hole made by it be sufficiently large.

(To be Continued.)

FOURTH ANNUAL REPORT OF THE PRESIDENT AND DIRECTORS TO THE STOCKHOLDERS OF THE L. C. AND C. RAILROAD COMPANY.

The last annual report from our much lamented President at Ashville, and the report from Mr. King, on whom devolved, for a time, the temporary management of the concerns of this company, at the adjourned meeting at Columbia in December last, exhibit a full statement of the condition and affairs of the Louisville, Charleston and Cincinnati railroad company up to those periods. The proceedings and resolutions of the stockholders at those meetings, as instructions to the board of directors, have since been fulfilled to their full extent, where obstacles probably unanticipated, did not interpose.

Upon application to the legislature of South Carolina, a loan of $600,000, in six per cent. bonds, as an advance upon the State subscription to the road, was obtained, and promptly applied, under the direction of my immediate predecessor in office, at its par value, to the extinguishment, in part of the company's obligations for the purchase of the Hamburg road.

An extension of the charter of the south western railroad bank for twenty years, within the limits of the State of South Carolina; and with a capital of three millions of dollars, was likewise granted, on the condition, that the road to Columbia be completed within three years from the first of January last. The surveys and operations beyond Columbia as directed, have been suspended, and the road to that place urged with all the despatch which the means of the company and State, and conditions of the contracts entered into would warrant. A system of economy and of retrenchment of expenditure has been commenced, and is maturing as rapidly as circumstances will permit. The engineers in service were reduced at the commencement of the year to four and since to three officers, and their salaries as prescribed, apportioned to the duties rendered. The other officers of the company are a President, a Secretary and Treasurer and a clerk, as few probably as could perform the duties devolving on them, increased as they have been by a system of finance which it has been found necessary to adopt. The progress with the road to Columbia imposed on the company by a due regard to its own interests, as well by the liberal additional grants of the South Carolina legislature to the enterprise, the exercise of the authority of the stockholders to the board of directors to issue obligations became necessary. They were the more inclined to this measure as it appeared to have met with the concurrence of the contractors, all of whom signed communications expressing their willingness to receive these promissory notes at twelve months date, drawing interest in payment for work done and materials furnished. To make them, however, available to the fullest extent, and subjected to the least possible depression in value, the denominations, with the approbation of the board, and at the request of the contractors, who could not readily dispose of the larger bills, were somewhat varied from those in the resolution, five, and twenty dollar notes being substituted for the fifty dollars; and in addition, small change bills of various denominations less than five dollars, (and which have proved an

accommodation to the road and the community,) have, to a limited amount, been issued,—and all of them without discrimination, been made receivable for dues to both the South Carolina canal and railroad, and the Louisville, Cincinnati and Charleston railroad companies. Circumstances have contributed favorably to the circulation of these obligations; and thus far they have so performed their functions as to enable this company to progress with the road. The system of credit, however, to rear up a work, which when finished will not probably yield an interest much greater than that paid for the money borrowed, is of very doubtful policy. It necessarily increases the cost of construction, and enhances incidental expenses. At any period it is objectionable, but particularly so when a general distrust of all paper issues, and of promises to pay, seem to pervade the community. The withdrawal, therefore, at maturity, of all the notes issued, and the prompt payment in cash of instalments as they become due, is recommended by the best interests of the stockholders, and credit of the company. The sooner the road is finished, and all the obligations contracted, extinguished, the sooner may its cost be estimated as capital invested, and on which remunerating dividends may be declared.

The calls for instalments on the road had been limited in the resolutions passed at Columbia, *to four*, and the periods fixed to the 1st of February, 1st of May, and 1st of November, 1840, and 1st of February 1841. At the time when this resolution was passed, and in conjunction with others, imposing on the direction the all important obligations of extinguishing the pressing debt to the South Carolina canal and railroad company; and the urging forward, with all possible despatch, the road to Columbia, accompanied with an application to the legislature of South Carolina for an advance of but $600,000, instead of for the whole remaining amount $800,000 of the State subscription, which with the same liberality no doubt would have been accorded, the committee of stockholders must have overlooked the detailed report of the chairman of the committee of finance at Ashville in September last, exhibiting the then immediate and pressing liabilities, of the company at $1,289,349.

The third instalment for the purchase of the Hamburg road due on the 1st of January, 1840, was alone $877,180. It required, therefore, $277,180 over and above the State advance, to extinguish this imperative engagement alone; and this could only be effected by a loan from the south-western railroad bank, with a pledge for re-payment, of the first receipts on instalments from the stockholders. This pledge, which afterwards interposed an obstacle to the receiving of the company's promissory notes from its stockholders in payment for stock, *and which was important to sustain their credit*, was subsequently relinquished in part by the bank, and without which confiding arrangement with that institution, the system of finance which had been resorted to, would probably have been seriously embarrassed. Though the ultimate liquidation of the past and accruing obligations of the company may, by these promissory notes, be advantageously postponed for a time; yet the continued confidence of the community in this paper, *which is necessary to its performing the functions for which it was intended* can only be sustained by the certainty, of that portion, which is not absorbed in payments of dues to the respective companies bound to receive them, *being redeemed at maturity*.

The calls for instalments therefore, as limited by the periods in the resolution passed at Columbia; rendering it very doubtful whether the receipts could be equal to the probable amount of paper required to be issued; and as the calls thereafter restricted by the charter to $5, at intervals of sixty days, would preclude the possibility of commanding the means ne-

cessary to complete the road to Columbia, within the period fixed by the legislature; your directors had the alternative presented of either suspending the work, and thereby loosing what had been done, and forfeiting the privileges extended to the south-western railroad bank; or of throwing themselves, at once, upon the powers of the charter; and of exacting payments from share owners every sixty days, until an amount equal to the obligations of the company could be raised. The latter measure after much deliberation, was preferred, as more in accordance with the increasing confidence in the enterprise; and with the best interests, and honor of the company represented by your board of directors. A pledge had been given, and those who subscribed their names to the promissory notes of the corporation, have now every guaranty, that they will be honored at maturity; and that the road will steadily progress to Columbia.

The subject of most intricacy and delicacy, one on which the board have not been able yet to act definitively; and which was brought, in a series of resolutions, to the notice of the company at the adjourned meeting at Columbia in December last, is the real relations of the several class of stockholders to the corporation of which they are, or were, in the first instance, members. The extent of their liabilities or exemptions, and the course dictated towards those who stand reported on the instalment book as defaulters. On this subject as directed, legal advice was taken by my predecessor Mr. M'Bee; and, although the opinion of an able counsellor seemed to give uncontrolled legal power over share owners, to the full extent of their subscription, yet it remained a question of great doubt with a great majority of the directors, how far it would be expedient, on the part of the company, to resort to a legal enforcement against those disposed to contend. If there were any doubts of the company's ability to meet ultimately all its engagements; if there were any misgivings as to its pecuniary responsibility, there might be an obligation, in justice to third parties; imposed, of of holding on to every name on the subscription lists, whether willing or not, as a member of the concern, and as equally liable individually for its engagements. To attempt, however, to enforce this through the courts of the country, and to bring the company in hostile array with many, who assert *forfeiture* as a privilege, to be exercised at their option, is a subject of most doubtful policy; not enforced by necessity, and not recommended by the interests of the company, or of those who are still willing to stand by and preserve their connection with it. That forfeiture, however, is a penalty, which on default of a stockholder, may be imposed by the company, is admitted by all. The charter is not ambiguous on that point—and whether it should not be applied at once against all those who refuse to contribute any more, and assert it as a privilege, is strongly recommended to the consideration of the stockholders—beginning with those who have paid but two instalments to the road; and so on extending the declaration of forfeiture gradually to those who are deficient on the other instalments until every willing delinquent is separated, as a member, from the corporators. It may be assumed, however, as a fact, which will be demonstrated in the result, that no share owner, who has paid three instalments on the road, and two in bank, will expose his shares to forfeiture.

(To be continued.)

Railway Fares are most profitable (whether high or low) when they fill the trains; because you can carry 200 passengers in a train for about the same expense that you can carry 40.

The question, then, is, how to fill up the trains; and it is found, by Parliamentary inquiry, in Great Britain, that the true way, in every instance, in various railways, is to put the fare low; and *that the low fare gives the largest nett income to the road.*